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THE AUTOIONIZATION EFFECT AND ITS INFLUENCE ON THE INTENSITY OF CERTAIN STAR SPECTRA LINES

By A. A. Nikitin

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THE AUTOIONIZATION EFFECT AND ITS INFLUENCE ON THE INTENSITY OF CERTAIN STAR SPECTRA LINES*

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It has been formerly noted (ref. 1) that the intensity of certain lines of star spectra may depend upon the excitement and ionization not only of outer but also of inner electrons. The atom, which after ejection of the inner electron is in a state of excitation, may return to the normal state either by way of quantum transitions or by way of radiationless transition, that is, by ejection of one or a few electrons from the outer shell. As it results from reference 2, these radiationless transitions (autoionization) are much more probable for light elements than transitions with emission of radiation.

If we admit the existence of a radiant field in a star shell capable of ionizing the atoms by inner electron ejection, such a process and the resulting ionization will have the following consequences:

1. Distribution of atoms by their state of ionization may in certain cases become anomalous, for instance, the spectrum may display lines of an element in a lower or upper stage of ionization, but lines related to intermediary stages will be weak or absent. The occurrence of another phenomenon is also possible. Elements with nearly or about the same outer electron ionization potential may actually be in a different stage of ionization. The known anomaly may be particularly noticeable if the radiation field is unsteady. In a nonstationary field there may be, in principle, some cases when emission lines of an element with a higher stage of ionization appear before those of the same element in a lower stage of ionization.

2. In the course of atom ionization with ejection of a K or L electron, the re-formed ion will not be in its normal state, but in an excited one. (Some of these ions are in a metastable state.) If this process is sufficiently intense, it will show up in a definite manner, by the brightness of the emission lines linked with the excited level.

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3. Because the autoionization is more likely to occur for lighter elements, its action must be particularly fully revealed for C, N, and O, as these elements are the most abundant and many of their spectral lines are within reach of study. The same will take place for certain ions of Fe and others having an electron structure similar to that of C, N, and O. For these ions, the autoionization is possible by ejection not of a single but of several electrons, and after such a process the resulting atom may be multiionized. We also must note that electrons formed after the autoionization possess greater energies, and this may have implications on the shell's electron temperature.

Let us now turn to observed data and begin with the investigation of new stars:

1. At a determined development stage of a new one, intense lines N II appear in its spectrum, and after a certain time some bright emission lines N III become characteristic; later, in a series of cases, there appear intense lines of emission N II (ref. 3). The development of a "nitrogen" spectrum in new ones is sometimes characterized by the appearance of lines NV in the area of absorption, with rapid variations of their intensity and position within the spectrum (ref. 3). It may be attempted to explain qualitatively these nitrogen spectrum particularities on the basis of the above considerations.

Under the action of radiation, particularly intense in the area ~400 ev, N II is ionized with ejection of a K electron and one of the outer shell electrons. Ion N IV, formed as a result of that process by recombination with electrons, emits N III and then N II. It must be noted that, together with the ionization process N II → N IV, the usual process N II → N III also takes place, as the coefficient of absorption and N II vary at the same slow pace as the frequency ν^{-1}. Observations point to a high intensity and variation of lines N III in the absorption area. The very same processes may bring additional contributions to the formation of ion NV. The ultraviolet radiation must also have an effect on other atoms and ions, having ionization potentials with K, L, and M at the 400 ev level. Ions Fe XIII to Fe XV, giving coronal lines, also fall in this group. As is known (ref. 3), in new spectra, together with the lines Fe V, VI, and so forth, the lines Fe X and Fe XIV were found. The same appearance of highly ionized lines CN, O, and Fe was recorded in spectra of other nonstationary stars (ref. 3), and, apparently, in the spectrum of the Sun and proturberances (ref. 4), where not so long ago lines O and N in a high stage of ionization were found. Observations (ref. 5) also show the presence in the solar spectrum of a variable Roentgen radiation, sometimes reaching a significant intensity.

2. Some ions, having formed as a result of atom inner ionization, were discovered in the outer layer of stars and nebulae. For instance, in the spectrum of Nebula NGC 7009 and others (ref. 6) were discovered

lines N III, which had formed from a recombination of the electron with ion N IV of the $1s^2\ 2s2p\ ^3P$ configuration (the normal configuration being $1s^2 2S^2\ ^1s$). Under determined conditions the recombination spectrum N III intensity may depend upon the ionization velocity of ion N III on account of the ejection of either S or p electrons. The structure of ion Fe XIV coincides with that of N III, its configuration being $1s^2 2s^2 2p^6 3s^2 3p$. The ionization of Fe XIV may also be realized so much on account of the ejection of 3p as of 3s electrons. In the latter case, Fe XV is formed in the state $3\ p^3P_{0.1.2}$ and its transitions between sublevels create the coronal line λ 7059 62, the intensity of that line being dependent on the investigated process.

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Other examples may be brought forth, namely, those showing that in the course of investigations of ionization processes and excitation in nonstationary stars it may be expedient in particular cases to include the examination of autoionization effects. The present paper dealt with the qualitative aspects of the question.

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